1979 HAMILTON AIR QUALITY

Ministry
of the
Environment

Ontario

1979 HAMILTON AIR QUALITY

TECHNICAL SUPPORT SECTION
WEST CENTRAL REGION

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SUMMARY

Air quality in Hamilton has improved significantly since 1970 in terms of long-term averages for most monitored pollutants. The main concern continues to be particulate matter. Suspended particulate levels dropped most perceptively during the 1972-75 period as shown in Figure 1, and this improvement is attributable to the control programs instituted by the major industries in conjunction with the Ministry of the Environment. Since 1975 though, levels have remained relatively stable and are still unsatisfactory in many areas of the city, especially near the heavy industry. However, the majority of the City does generally experience acceptable quality. Soiling index showed a similar decline as suspended particulate, however, dustfall levels have surprisingly shown no improvement at all during the 1970's and remain well above objectives in a large part of the city.

As mentioned above, while air quality has improved in the long-term, there continue to be problems in the short-term, especially during atmospheric inversions. During 1979, there were 22 instances of the air pollution index reaching or exceeding 32, all during inversions. In the previous few years, there were seven to ten such incidents each year and none matched the severity or duration of some of the 1979 occurrences, indicating that the entire city is still very susceptible to periods of high pollutant levels.

Levels of sulphur dioxide, carbon monoxide and oxides of nitrogens remained acceptable in 1979 with all objectives being met.

Reactive (non-methane) hydrocarbons have remained constant over four years of measurement. However, there is some question as to the validity of the data.

Levels of total reduced sulphur continued in 1979 to show readings above the objective, mostly during inversion conditions. These are the pollutants which usually cause the occasional odour problems that the City still faces.

Ozone levels have remained relatively constant over the 1975-79 period, although a slight decline occurred in 1979, probably due to a relatively cool summer. Ozone, a secondary pollutant arising from photochemical

reactions in the atmosphere, is a regional problem and elevated levels above the objective have been recorded throughout Southern Ontario and the United States. Ozone can be transported over long distances away from the sources of its precursors and be augmented by locally produced ozone. Most of Southern Ontario's high levels seem to be caused by long-range transport from the United States. In Hamilton, concentrations are generally lower than in other localities, probably due to the numerous high temperature combustion sources in the city which produce higher levels of nitric oxide, a scavenger of ozone.

Sulphur and fluoride emissions stem mostly from industrial sources as indicated by sulphation and fluoridation rates, both of which continued to show elevated levels near the industrial area in 1979. There are no sulphation objectives and, based on past phytotoxicology studies, it is improbable that the fluoride levels were high enough to cause vegetation damage.

INTRODUCTION

The Air Management Program in Ontario is based on controlling man-made emissions to meet ambient air quality objectives, which in turn are based on known effects on health, quality of life or sensitive vegetation, whichever is most stringent. To achieve these objectives, sources of pollution are identified, their emissions evaluated and appropriate control measures are instituted. Ambient air monitoring is then used to verify that the controls have been successful. Monitors are mainly sited in areas suspected of experiencing higher levels of air pollution. If and when these areas achieve acceptable air quality, then other areas should also be acceptable.

Inventories of emissions from major pollution sources are maintained and can be used in mathematical modelling to predict pollutant concentrations at any given point in the atmosphere; however, more importantly, this inventory allows for an evaluation of the control programs and strategies through comparison of emissions to ambient air quality trends.

MONITORING NETWORK

The Ministry of the Environment operates a network of ambient air monitoring throughout Hamilton as shown in Figure 2. Monitoring is most concentrated in the lower city, that is the area below the Niagara Escarpment and the network is centered on two major stations which monitor a variety of pollutants with mostly automated analyzers. The main station, known as 29025 - Barton/Sanford provides the data which forms the basis for the Hamilton Air Pollution Index (API). The other major station is on the Beach Strip and is known as 29008 - North Park, immediately adjacent to the Queen Elizabeth Way. The remainder of the network consists of numerous but mostly less sophisticated monitors. Most of the network has been in existence since at least 1970. Besides this regular network, special surveys are carried out occasionally in order to identify specific problems.

Meteorological data (wind speed and direction and temperature) are observed at station 29026, located on the sewage treatment plant grounds on Woodward Avenue. We consider this location to be more representative of local conditions than the Federal Government's Mount Hope Weather Station due to the complex meteorological patterns which sometimes prevail in Hamilton. This feature will be addressed later on in this report.

AIR POLLUTION INDEX

The Hamilton Air Pollution Index (API) is used as a warning system to alert the public to elevated air pollutant levels. It is derived from 24-hour average concentrations of sulphur dioxide and particulate matter as measured at the Barton/Sanford Station. The combination of these two pollutants has been shown to be at least indicative of detrimental human health effects. No action is taken for readings up to 31. At 32, known as the advisory level, and with a forecast of unfavourable dispersion conditions, major emitters are notified and asked to voluntarily curtail certain operations. At an API of 50, cutbacks by these sources become mandatory. These alert levels are set with a considerable safety margin before documented health effects should take place.

The API station is located halfway between downtown and the heavy industry and is directly downwind of the industrial area during times of poor atmospheric dispersion. Due to differences in station locations in relation to local sources, inter-city API comparisons are rather tenous and, therefore, caution must be exercised in their interpretation.

During 1979, there were 22 different instances of the API reaching or exceeding 32 as listed in Table 1. In previous years, there were about 7 to 10 such incidents per year, but none matched the severity or duration of some of the occurrences in 1979. This does not, however, represent any deterioration of industrial emissions which were, in fact, essentially unchanged from 1978, but reflects a greater frequency of times when poor atmosphere dispersion conditions (eg. low wind speed and/or the presence of inversions) prevailed. The majority of the incidents occurred in the spring and fall and were related to inversions formed when cool air blew off the lake often in combination with frontal inversions associated with storm systems.

The dispersion of pollutants in the atmosphere is restricted when an inversion (the increase of air temperature with height) is present in the lower atmosphere. There are four types of inversions of which three are important in causing high API levels in Hamilton: advection inversions, frontal inversions, and subsidence inversions. In Hamilton, advection inversions may often occur in conjunction with frontal or subsidence

inversions. The prime cause of advection inversions in Hamilton is the flow of cool air from over the lake into the City. This layer of cooler and denser air usually is high enough to extend above the escarpment (Figure 3). Warmer and less dense air coming from the south flows over the cool air in the City forming the inversion interface. Mixing of air within the cool air is severely restricted and, therefore, little pollution is lost from the stable layer. In addition, the wind off the lake is quite weak. As a result, normal industrial emissions drift over the City and begin to build due to the lack of ventilation. The December 21-22 incident in which the API exceeded 50 was due to such an inversion. What made this episode so severe was the fact that the inversion was very strong and shallow and remained so for most of the incident, thus concentrating the pollutants near the ground much more than usual. This was the first incident since 1970 that the Index exceeded 50.

Frontal inversions, illustrated in Figure 4, occur along the boundary of a warm and cold air mass. In the case of warm frontal inversion, a warm air mass overtakes and over-rides a cold air mass forming a gently sloped inversion layer that may extend hundred's of kilometres. Because the winds generally associated with warm fronts in Hamilton blow from the east across the lake, warm frontal inversions are often accented by advection inversions. Several of the periods when the Hamilton API exceeded 32 occurred on days when frontal inversions were present.

Subsidence inversions are caused by the slow descent of air from higher elevations in the centre of high pressure systems. This descending motion causes the air in an elevated layer to be compressed thereby increasing its temperature and forming an inversion layer aloft. Because these inversions are most often formed in slow-moving or stationary high-pressure cells, the air mass accumulates a high burden of pollutants from over a large area. The pollutants brought into Hamilton from outside the City combined with local emissions can lead to high API levels. During March 20-24, 1979, one such system lingered over the area for five days and, with the enhancement by an advection inversion over the City accounted for the most prolonged incident of the year - a total of 91 hours above 31.

PARTICULATES

There are three methods for the measurement of particles, each method relating to a different size range. Dustfall jars measure heavy material, generally greater than 10 microns in diameter. High volume samplers measure suspended particulate ranging in size from submicron to 50 microns and co-efficient of haze tape samplers measure mostly fine material - from submicron to about 10 microns.

The ambient air quality objectives for suspended particulate and soiling are based on health effects when occurring in combination with sulphur dioxide. As mentioned previously, this combination was proven to be indicative but not necessarily causative of such health effects. The dustfall objectives are based on nuisance effects.

A high volume sampler draws a known volume of air through a pre-weighed filter for a 24-hour period (midnight to midnight). The exposed filter is weighed and the difference in conjunction with the known amount of air flow is expressed as concentration in micrograms per cubic meter. At two locations in Hamilton, these devices operate daily. At all other locations, they run on a once every sixth day cycle.

Suspended particulates at the nine established Hi-Vol locations (Table 2a) generally showed little change in 1979 from previous years except at a downtown location where the yearly geometric mean increased from 64 to 78 ug/m^3 and in the west end at Chatham/Frid where the mean increased from 77 to 91. It must be assumed that these locations were affected by local sources due to the lack of change at the other stations. The other stations generally showed levels marginally to excessively above objectives depending on distance from the industrial area. The Barton/Sanford and North Park hi-Vols once again showed unacceptably high means of about 100. The Burlington/Leeds station in the heart of the industrial area once again, as in 1978, was severely affected by excavation and construction activities in the immediate vicinity of the monitor throughout most of the year. The geometric mean of 120 was probably only indicative of a very local area. Without the interference, the levels would probably have been similar to Barton and North Park.

Two new stations were established in April. On the mountain, the nine month geometric mean at the Upper Wellington/Inverness Police Station was 61. If the first three months had been monitored, the mean probably would have been below the objective of 60 indicating acceptable levels on the mountain. The other new station was located at the base of the escarpment on Cumberland Avenue near Gage Park. Its mean of 73 would probably reduce to less than 70 with a full year's sampling, moderately above the objective.

McMaster University also carried out hi-Vol sampling during 1979 as part of their study on the health effects of air pollution. Their six day sampling coincided with the Ministry sampling schedule. Table 2b gives the results of six stations that monitored all or mostly all of the year. The monitors are generally situated in residential areas on the mountain, the west end and east end of the city and act as a supplement to our network. The data on the mountain were quite uniform with acceptable yearly means of 44-55 at three stations, corroborating the single Ministry hi-Vol's results. The west end also showed acceptable levels of 55 on Whitney Avenue and 51 near Aberdeen Avenue. In the east, on Pottruff Road, the mean was an acceptable 52.

A noteable observation is that the maximum value at all stations occurred on March 22 during the subsidence inversion discussed earlier. This indicates that during most inversions, all parts of the city, including the far reaches of the mountain are affected by industrial and other general City activity emissions due to the lack of ventilation. Based on air pollution complaints received, it is probable that in most cases, the inversion layer does extend above the level of the escarpment. However, there were no other inversion periods that coincided with the six day schedule to corroborate this.

Co-efficient of haze tape samplers operate continuously and can determine hourly or two-hour average soiling values. Air is drawn through a filter paper and the optical density of the soiled spot is measured by light transmittance. Unfortunately, the one-hour telemetered instruments have been demonstrated to yield values at least 25% higher than the two-hour instrument for equal samples of air and hence, the two types of measurement are not directly comparable. Due to this unresolved difference, the two-hour data are presented separately from the one-hour data.

The main station on Barton Street and the North Park Station both employ one-hour instruments. The yearly means in 1979 were both above the objective and the daily objective was exceeded frequently; 73 times at North Park and 55 times at Barton. The data is summarized in Table 3a. Both stations exhibited a 10% increase in the yearly average from 1978 and while the high frequency of inversions may possibly account for this observation at the Barton station, it is unlikely that this can be said for North Park. The increase here is unaccounted for.

Six other stations employ 2-hour instruments (Table 3b) and all recorded yearly means below the objective. Most stations showed the same small increase in levels as Barton and North Park did.

Dustfall is that material which settles out of the atmosphere by gravity and is collected in plastic containers during a 30 day exposure time. The collected material is weighed and expressed as a deposition rate of grams/square meter/30 days. The significance of observations is restricted to relatively local areas.

Dustfall levels in 1979 (Table 4) remained similar to those of previous years. Figure 5 depicts dustfall isopleths and shows that a large part of the lower city and the Beach Strip was encompassed by the 9.0 grams/m^2 contour which represents twice our objective. Conditions in this area, for the most part, were quite poor. The significance of re-entrainment to dustfall loadings is shown by the lower loadings in January when there was snow cover on the ground. The January average for all stations combined was 7.4 grams compared to an overall year long average of 9.6 grams. The other winter months (February and December) are not included in this comparison due to the well below normal snow fall during these months (as per the Mount Hope Weather Office's records).

It is noteworthly that as shown in Figure 1, dustfall levels throughout the City have remained virtually unchanged throughout the 1970's, despite considerable reductions in industrial process emissions.

SULPHUR DIOXIDE

Most sulphur dioxide (SO_2) emissions in Hamilton, as detailed by the emissions inventory, stem from industrial sources. Only a small portion is accounted for by fuel burning in domestic space heating. The Barton/Sanford and North Park Stations monitor SO_2 continuously and data is summarized in Table 5.

The levels at both locations have been generally acceptable in recent years. In 1979, the yearly means remained below our objective. As well, the hourly and daily objectives were not exceeded throughout the year. These SO_2 objectives are based on vegetation damage which is a more stringent limitation than health effects.

TOTAL REDUCED SULPHUR

This pollutant was formerly identified as hydrogen sulphide (H_2S). However, since the analyzer also reacts to other sulphur compounds, the data is now reported as total reduced sulphur. The objective for hydrogen sulphide can still be applied to the observed values and is based on the odour threshold level. Both Barton/Sanford and North Park monitor continuously and the data are summarized in Table 6.

The major sources of hydrogen sulphide and related sulphur compounds are the steel industries' coke ovens, certain slag reclamation processes and under upset conditions, a local manufacturer of carbon black. Another potential but rather minor source is Windermere Basin. Sulphur bearing organic sediments from Redhill Creek and a sewage overflow from the sewage treatment plant may under certain adverse conditions during the spring, decompose and produce hydrogen sulphide. The sewage treatment plant itself is another minor source, but only during certain upset conditions when similar undesirable decompositions of sewage can occur.

The levels of 1979 were similar to 1978. Although Barton's average increased from .0016 ppm to .0024 ppm, this actually represents only a minor change. The more relevant statistic to observe is the number of values above the hourly objective for H_2S (.02 ppm). There were 75

hours at Barton and 3 at North Park above .02. The high concentrations at Barton often occurred during inversions, but there were also several readings when inversions were not a factor. There were not as many high values at North Park since southwest winds even though predominant, normally offer good dispersion of emissions. These are the pollutants which usually cause the occasional odour problems that the City still faces.

During the afternoon of April 21, five consecutive hours of extremely high readings were recorded at the Barton station. The maximum for the year occurred during this time. The source could not be traced and quite unusually, there were no odour complaints.

CARBON MONOXIDE

The major source of carbon monoxide emissions is the automobile. However, in Hamilton there are also some contributions from industry. Due probably mainly to automotive emission controls, the levels measured at Barton Street (Table 7) decreased greatly over the 1970-75 period. Since 1975, the levels have remained relatively stable, well below objectives. In 1979, no change was observed. The objectives for this pollutant are based on health effects.

OXIDES OF NITROGEN

The primary source of oxides of nitrogen are high temperature combustion sources. The most abundant oxides are nitric oxide (NO) and nitrogen dioxide (NO_2) and they are monitored continuously at both Barton/Sanford and North Park. At each station, a single instrument makes measurements of NO, NO_2 and total nitrogen oxides. Nitric oxide is measured directly and the total oxides are measured by internally converting all other nitrogen oxides to nitric oxide. The instrument then determines nitrogen dioxide to be the difference between the first two measurements.

Of the three reported pollutants, objectives exist only for nitrogen dioxide and these are based on the odour threshold and health effects.

While nitrogen dioxide and total oxides have decreased since 1977 (Tables 8 and 10), the levels are actually just returning to their former levels of 1975. There were no exceedences of the NO_2 objectives in 1979. This peaking in 1977 was common to many other locations in the province and is not readily explained.

Concentrations of nitric oxide have remained stable over the same period and are given in Table 9.

Similar to previous years, NO_2 levels were similar at each station but NO levels were about 2½ times as high at North Park than at Barton. This could perhaps be explained by North Park's close proximity to the Q.E.W. Most vehicular emissions of oxides of nitrogen consist of NO which later is oxidized to NO_2 in the atmosphere. The North Park station probably monitors the NO before this conversion can fully take place.

Oxides of nitrogen are an important factor in the photochemical production of ozone which will be discussed later in this report.

HYDROCARBONS

In Hamilton, hydrocarbon emissions are associated with industrial sources as well as with automobiles. There is a considerable quantity of hydrocarbons being produced by natural sources, such as methane due the decomposition of grasses, plants and trees. Our concern, however, is mainly with the man-made portion of this pollutant which can react with other substances under appropriate climatic conditions to result in secondary pollutants. The man-made portion comprises a considerable and variable number of substances and is referred to as non-methane or reactive hydrocarbons. Only the non-methane portion of the pollutants have been monitored at Barton since 1976.

During the four years of measurement, the levels have remained stable but relatively high compared to other communities. Data are summarized in Table 11. Analysis of wind data did not reveal any particular source(s) to be the cause of high levels. Rather, the levels were relatively uniform for all wind directions. This might tend to indicate that automobiles are the most significant source in Hamilton.

At the moment, there is some doubt as to the validity of this data and potential problems with the instrument are being investigated.

No objectives exist for these pollutants, however, the monitoring is important for trend purposes and strategy planning as well as for hydrocarbons' importance in the photochemical production of ozone.

OZONE

Oxidants are mainly a product of photochemical reactions involving oxides of nitrogen, hydrocarbons and sunlight. Ozone accounts for most of the oxidants produced. The sources of the precursor pollutants are mainly industrial and automotive.

Ozone is known to be associated with many respiratory problems and at elevated concentration people can experience adverse health effects. Ozone is also injurious to different types of vegetation including certain tobacco and tomato crops. The one-hour objective for ozone (.08 ppm) is based on both health and vegetation effects.

Ozone concentrations follow very definite annual and daily trends. Highest levels occur during the summer (May-September) and the daily maximums usually occur during mid afternoon. Both patterns are directly related to the amount and intensity of sunlight.

During 1979, Southern Ontario experienced fewer exceedences of the hourly objective than in previous years. In Hamilton (Table 12), there were 32 hours above .08 compared to 71 in 1978, and all occurred during June and July. These high concentrations were widespread, occurring concurrently throughout the region and were considered usually to be a result of long-range transport from the United States. The decrease in the number of high values can probably be attributed to the relatively cool summer which was not conducive to oxidant formation.

Ozone, hydrocarbons and oxides of nitrogen can be transported over great distances and be augmented by local sources. However, Hamilton and other major urban areas usually experience lower ozone concentrations than their more rural surroundings during peak occurrences. In

fact, the concentrations in Hamilton are among the lowest recorded in Southern Ontario, probably due to the numerous high temperature combustion sources which produce higher levels of nitric oxide, a scavenger of ozone. Nevertheless, ozone and other oxidants remain a problem which due to the complexity of their formation and the long-range transport phenomenon, will have to be resolved on a regional rather than local scale.

SULPHATION

Sulphation rate is a crude measurement used to determine relative quantities of various sulphur compounds in the ambient air. A paper coated with lead peroxide is exposed to the atmosphere for approximately 30 days and then chemically analyzed for sulphur. The results are reported as depositions of sulphur trioxide. Initially, a sulphation objective existed and was based on the sulphur dioxide yearly goal. However, the correlation between sulphation rate and sulphur dioxide depends on the type and number of different compounds involved, and because of this variability, the sulphation objective was dropped in 1979. As well, in 1979, a change in methodology was made by substituting "plates" for "candles". The change was made for reasons of economy and ease of analysis. However, it has been established from side-by-side exposures, that plates read on the average about 30% higher.

Although the measurement is crude, it is useful for trend determination purposes as well as detecting severe pollution problems which call for more sophisticated instrumentation.

The 1979 data given in Table 13, showed higher concentrations than 1978, however, the "increase" can be attributed to the change in the method of measurement rather than deterioration of air quality. The overall average was .68 in 1979 and .52 in 1978 - a difference of 31%.

As to be expected, levels were highest in the industrial area, however, one unusual aspect of the data is the strangely high values recorded in November throughout the city. Levels at more distant locations such as on the mountain and the west end were as high as those in the north end during this month.

FLUORIDATION

This measure is a crude assessment similar to that for sulphation. A lime coated paper is exposed to the atmosphere for approximately 30 days and is then chemically analyzed for fluoride. The fluoride objectives are based on vegetation damage, and for this reason, the objective is more stringent during the growing season. For the period of April 15 to October 15, it is 40 mg/100 square centimeters/30 days while for the remainder of the year it is 80.

In Hamilton, the major fluoride sources are the basic oxygen furnaces used by the major steel industries which require fluorspar as a fluxing agent. In addition to these process emissions, there are other minor sources such as coal burning since coal contains trace amounts of fluoride.

In 1979, fluoridation levels, given in Table 14, dropped back by 25% to the levels observed in 1977. It was initially felt that the increase in 1978 was possibly due to increased steel production. However, in 1979, production was increased even slightly more and yet fluoride levels were reduced. These unaccountable fluctuations may simply reflect the insensitivity of the measurement.

In any case, based on past vegetation studies, it is unlikely that the levels affected local plant life.

RESEARCH STUDIES

A study by the Ontario Research Foundation funded mainly by the Federal and Provincial Governments is now underway, aimed at identifying the type and origin of dust particles in Hamilton's air, including the effect of road dust and its re-intrainment by wind and traffic . The basis for the study is the fact that during recent years, improvements in air quality have not been proportional to abatement efforts by government and industry. It appears that there is a limit to further air quality improvements which can be achieved through control of traditional sources and that abatement measures which could be undertaken are becoming increasingly costly and decreasingly efficient. The study is expected to result in sound scientific information on the proportion of air pollution attributable to industrial and non-industrial sources and will determine the best cost-effective control strategies.

Also, McMaster University is carrying out a three year provincially and federally funded study which will attempt to determine by extensive breathing tests, the respiratory health of 3,800 Hamilton school children and will relate these data to air quality measurements. The project will also inter-relate other factors, such as indoor environment, which may affect the children's repiratory health. Results of the study will provide evidence in establishing sound criteria, standards and indices for ambient air quality based on actual health effects.

DISCUSSION

Despite significant reductions in pollutant levels from the early 1970's, levels of some air pollutants, especially particles, remain unacceptable in many parts of the city. Little improvement has occurred since 1975. Although inventoried industrial process emissions have decreased moderately over this time, the effect on measured pollutant levels has been negligible. In fact, dustfall levels have not changed at all since 1970. This indicates that apart from the remaining process emissions (for some of which, abatement technology must still be developed), other pollution sources on which no emphasis has yet been placed, may have to come under control. These sources, sometimes referred to as "fugitive", can be both industrial and non-industrial in nature such as blow-off from stockpiles, unpaved areas, excavation and construction activities, material handling and road traffic.

The events of 1979 reveal that at the moment, although the majority of the city generally experiences acceptable air quality in terms of long term averages, the entire city is still very susceptible to periods of poor atmospheric dispersion. During these times, pollutant levels can become intolerable for many people, and despite industry's past efforts toward pollution abatement, more will have to be done in future in order to help alleviate the problem.

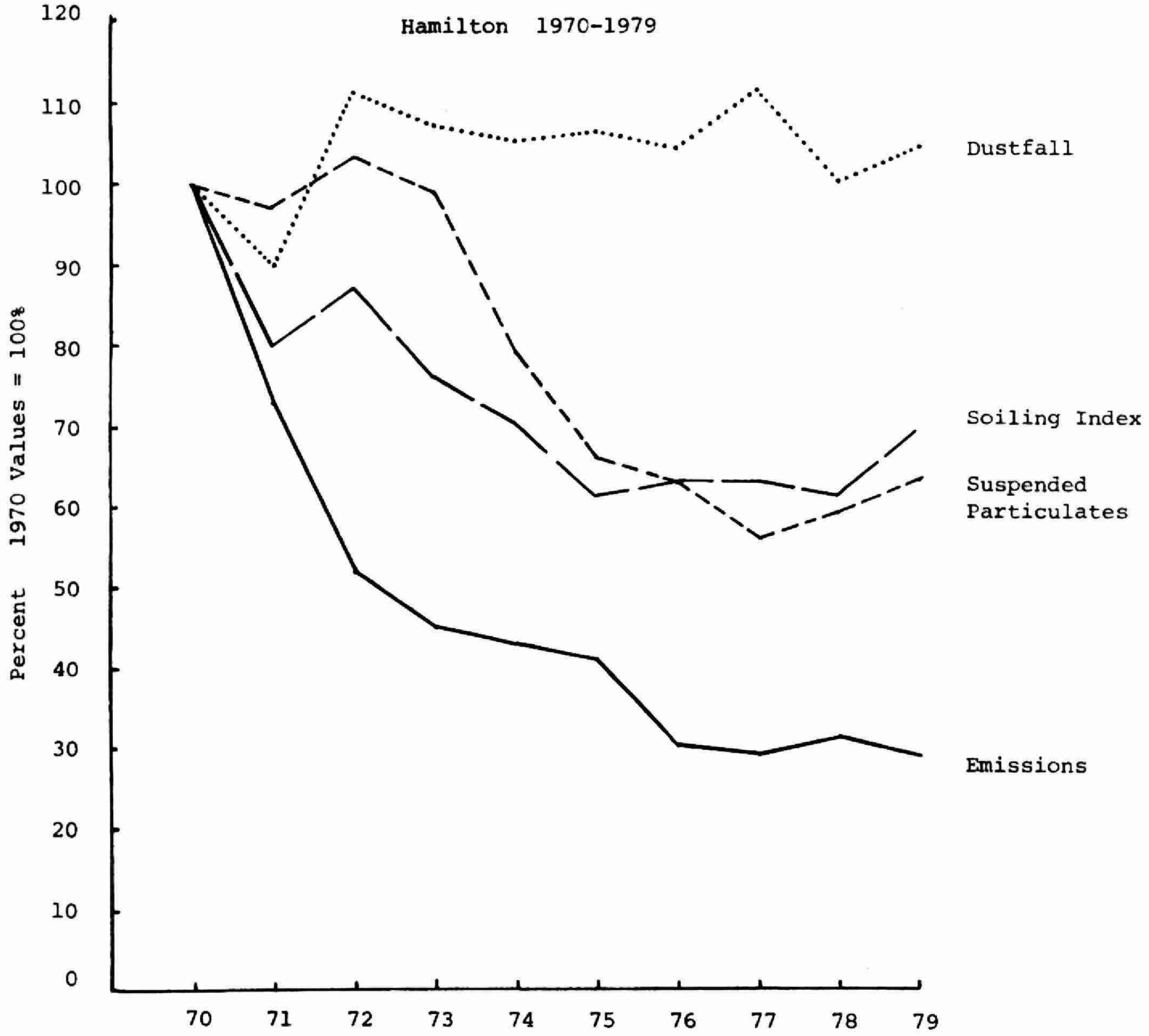
ACKNOWLEDGEMENT

We would like to thank Mr. Stephen A. Toplack of the Urban Air Environment Group at McMaster University for providing their suspended particulate data.

FIGURE 1

Particulate Trends vs Estimated Total Emissions

Hamilton 1970-1979



	70	71	72	73	74	75	76	77	78	79	
Suspended Particulates (7 station)	131	127	135	130	104	86	83	73	77	82	$\mu g/m^3$
Dustfall (17 stations)	9.4	8.5	10.4	10.1	9.9	10.0	9.8	10.4	9.4	9.8	g/sq.m/30days
Soiling Index (7 stations)	.54	.43	.47	.41	.38	.33	.34	.34	.33	.37	COH's/1000ft.
Institutional & Industrial Emissions	56	41	29	25	24	23	17	16	17.5	16	10^6 lbs/year

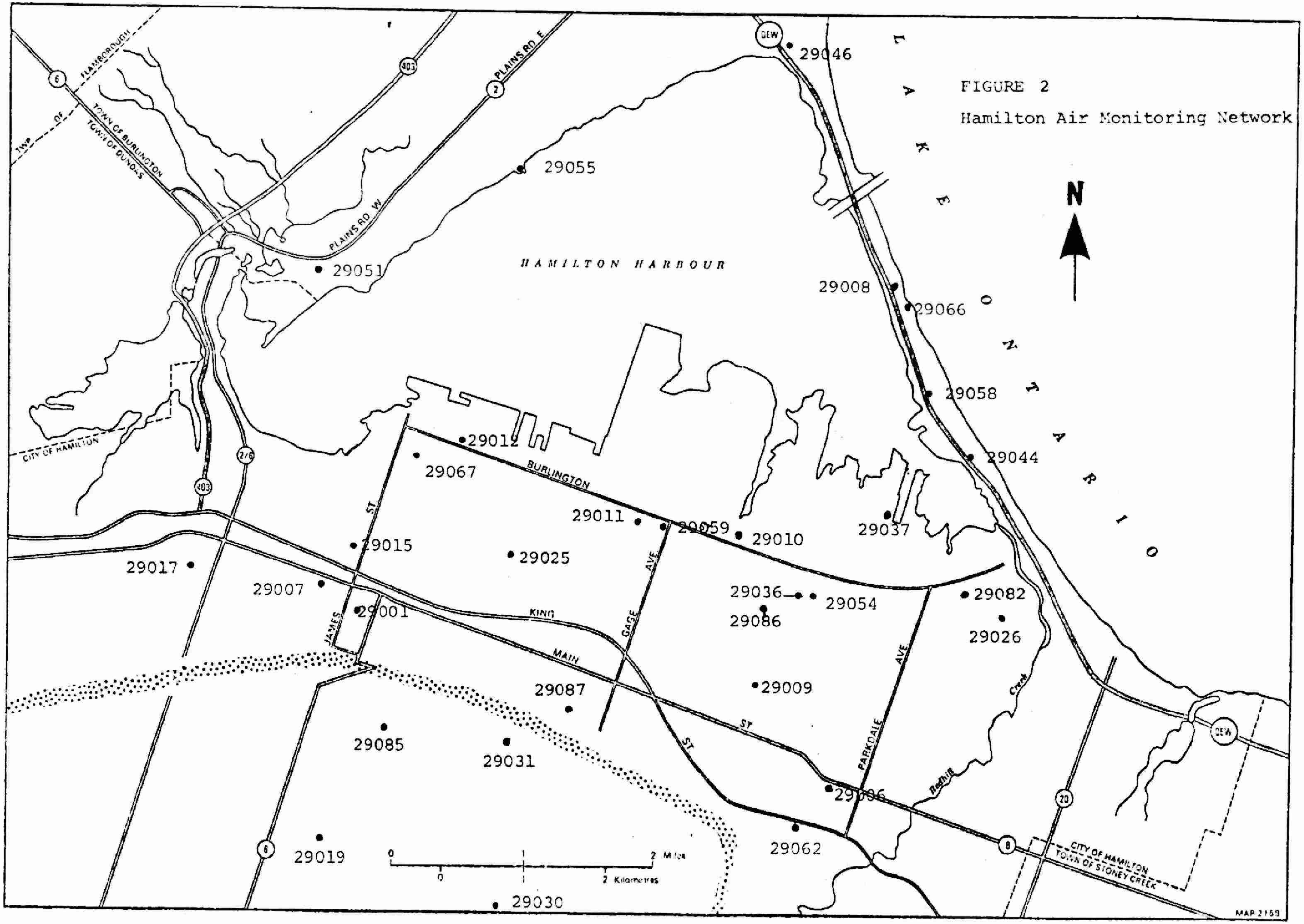


FIGURE 2

Hamilton Air Monitoring Network

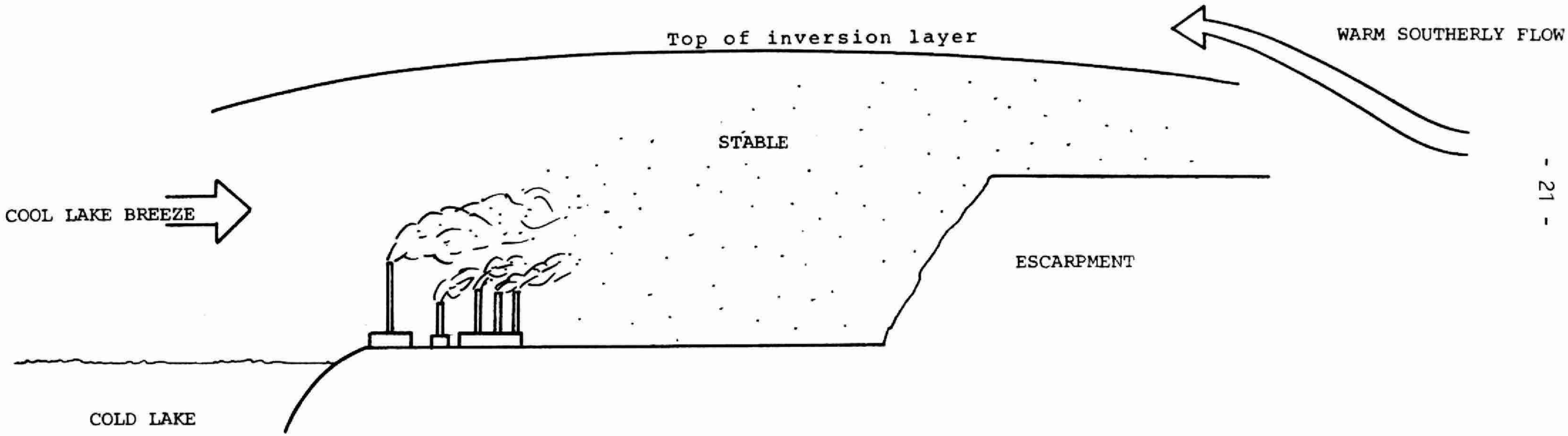


FIGURE 3

LAKE INDUCED ADVECTION INVERSION

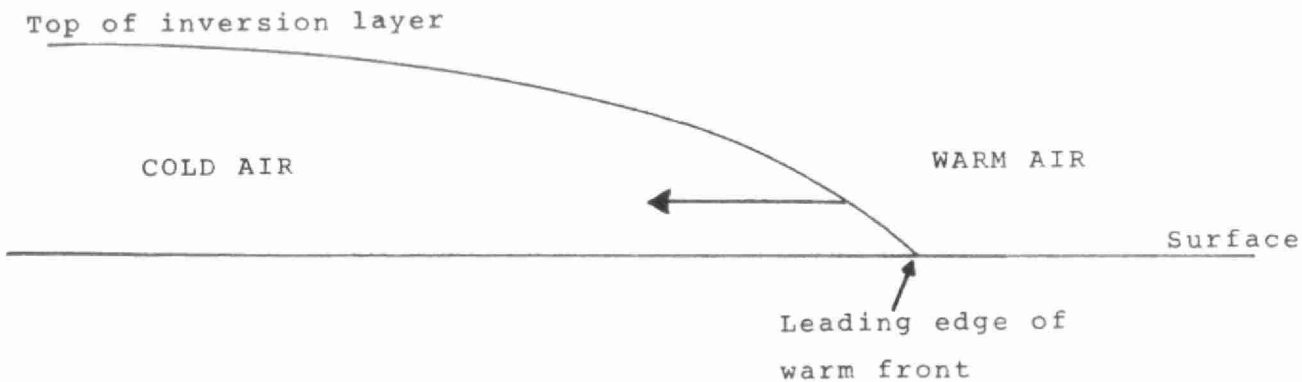


FIGURE 4

FRONTAL INVERSION

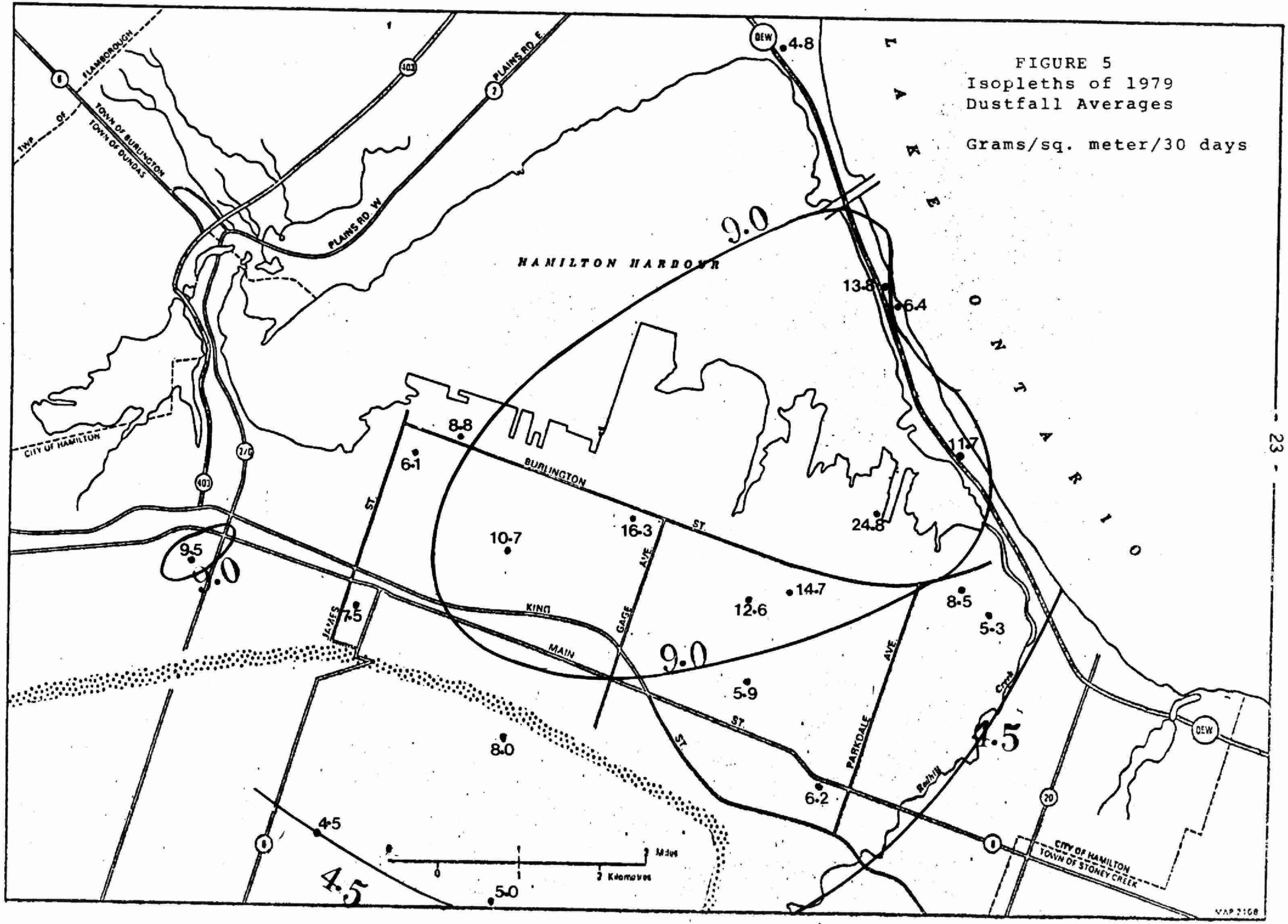


FIGURE 5
Isopleths of 1979
Dustfall Averages

Grams/sq. meter/30 days

TABLE 1

AIR POLLUTION INDEX

OCCASIONS WHEN 32 OR MORE

1979

Number	Date	Maximum	No. Hours ≥ 32	No. Hours ≥ 50
1	Feb. 21	34	13	
2	Feb. 23	34	10	
3	Feb. 26	32	1	
4	Mar. 1 – 2	37	15	
5	Mar. 20 – 24	41	91	
6	Apr. 11 – 13	39	50	
7	Apr. 23 – 25	42	60	
8	May 2 – 3	32	5	
9	May 7 – 8	37	41	
10	May 11 – 12	39	21	
11	May 18 – 19	35	17	
12	May 24	33	2	
13	June 1	34	20	
14	June 7 – 8	38	21	
15	Oct. 3	33	4	
16	Oct. 16 – 18	33	18	
17	Oct. 31 – Nov. 1	34	14	
18	Nov. 6 – 7	33	10	
19	Nov. 18	32	4	
20	Nov. 20	34	9	
21	Nov. 26	34	11	
22	Dec. 21 – 22	55	43	14

TABLE 2a

SUSPENDED PARTICULATES

UNITS - MICROGRAMS PER CUBIC METER

ONTARIO OBJECTIVES: 24-hour - 120
1-year Geo. Mean - 60

	No. of Samples	Geometric Mean			Maximum	No. of Times Above 120
		1979	1978	1977		
29001 - Hughson/Hunter	56	78	64	63	317	8
29007 - City Hall	56	60	61	54	233	3
29008 - North Park	307	96	93	94	316	102
29009 - Kenilworth	59	69	70	61	260	4
29011 - Burlington/Leeds	58	120	133	95	340	30
29012 - Burlington/Wellington	56	76	74	70	173	9
29017 - Chatham/Frid	58	91	77	72	369	13
29025 - Barton/Sanford	319	100	102	96	486	110
29067 - Hughston St. N.	54	62	63	59	146	3
29085 - Mountain Police Station	43	61[9]	-	-	150	3
29087 - Cumberland	43	73[9]	-	-	184	6

TABLE 2b

McMASTER UNIVERSITY SAMPLING

SUSPENDED PARTICULATES

MICROGRAMS PER CUBIC METER

ONTARIO OBJECTIVES: 24-hour average - 120
1-year Geo. Mean - 60

LOCATION	No. of Samples	Geometric Mean	Maximum	No. of Times Over 120
San Diego Court	57	47	190	2
Upper Ottawa/Mohawk	59	44	190	1
Aberdeen/Undermount	57	51	243	4
Whitney/Rifle Range	46	55	163	2
Potruff/Queenston	50	52	134	1
McElroy/Upper Wellington	52	55	168	1

TABLE 3a

SOILING INDEX - 1979

1-HOUR TELEMETERED INSTRUMENTS

UNITS - COH's per 1000 linear ft. of air

Ontario Objectives - 24-hour - 1.0
1-year - 0.5

	Annual Average 1979	1978	1977	1976	Maximum 24-hour	No. of Times Above Objective 24-hour
29008 - North Park	.73	.67	.63	.55*	2.0	73
29025 - Barton/Sanford	.63	.56	.54	.53	3.1	55

* July - December, 1976

1-hour telemetered data not directly comparable to 2-hour data - see text

TABLE 3b

SOILING INDEX - 1979

2-HOUR INSTRUMENTS

UNITS - COH's per 1000 linear feet of air

Ontario Objectives - 24-hour - 1.0
1-year - 0.5

	Annual Average 1979	1978	1976	1976	Maximum 24-Hour	No. of Times Above Objective 24-Hour
29001 - Hughson/Hunter	.32	.25	.28	.28	2.3	4
29009 - Kenilworth	.18	.15	.20	.25	1.3	1
29012 - Burlington/ Wellington	.18	.16	.26	.24	0.6	0
29015 - Merric/James	.28	.28	.26	.31	2.0	2
29017 - Chatham/Frid	.29	.25	.20	.30	1.6	1
29067 - Hughson N.	.24	.23	.22	.25	1.5	1

2-hour data not directly comparable to 1-hour telemetry data - see text

TABLE 4

DUSTFALL 1979

UNITS - GRAMS/SQ. METRE/30 DAYS

Ontario Objectives - 1 month avg - 7.0
1 year avg - 4.5

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average 1979	Average 1978	Average 1977
29001 Hughson/Hunter	4.6	7.8	11.6	10.6	9.2	9.3	5.5	6.0	6.7	6.5	-	4.8	7.5[11]	6.5	8.2
29006 Queenston	4.8	6.6	9.2	8.6	5.1	10.5	4.1	4.5	5.1	4.2	5.6	5.5	6.2	8.0	9.1[10]
29008 North Park	19.6	16.2	17.6	10.8	7.5	9.1	11.0	9.5	12.9	15.3	18.1	17.4	13.8	12.6[11]	17.7
29009 Kenilworth	5.8	8.0	7.5	9.1	1.8	8.8	5.8	5.2	5.2	5.3	4.8	3.5	5.9	6.1	6.4
29010 Burlington/Ottawa	-	-	-	-	-	-	13.6	16.9	-	-	22.0	17.2	17.4[4]	14.4[9]	14.6
29011 Burlington/Leeds	8.7	21.2	22.3	22.2	18.0	20.5	13.8	14.3	13.8	13.9	15.1	11.7	16.3	14.9[11]	14.6
29012 Burlington/ Wellington	6.9	10.8	-	12.7	10.6	9.6	8.1	6.9	8.5	7.4	6.2	-	8.8[10]	10.4	11.1
29017 Chatham/Frid	6.8	5.6	18.2	11.4	9.4	10.0	8.6	8.3	8.0	7.5	9.6	10.2	9.5	10.6	10.3
29019 Mohawk/Warren	2.4	2.6	8.3	4.7	4.3	6.8	4.6	3.3	5.6	3.7	4.1	3.9	4.5	4.2[11]	6.1
29025 Barton/Sanford	7.1	10.6	16.0	12.8	13.7	11.1	-	-	9.4	10.9	8.8	6.7	10.7[10]	9.5	11.5
29026 Woodward/Brampton	5.0	6.0	7.6	6.4	5.0	6.4	3.7	4.1	3.8	5.2	4.7	5.1	5.3	5.0	5.0
29030 Camden/Mohawk	2.3	4.0	8.5	6.2	5.6	6.6	4.1	4.1	4.5	5.4	4.9	3.7	5.0	6.3	6.5
29031 Concession/ Upper Sherman	5.2	11.5	13.3	12.0	8.7	8.2	4.9	6.4	6.5	5.8	6.6	7.2	8.0	7.5	7.2

- Underlined values are above objective

TABLE 4 (Cont'd)

DUSTFALL 1979

UNITS - GRAMS/SQ. METRE/30 DAYS

Ontario Objectives - 1 month avg - 7.0
1 year avg - 4.5

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average 1979	Average 1978	Average 1977
29036 Roosevelt/Beach Rd.	7.3	9.6	16.8	20.8	15.0	19.2	9.8	7.3	8.9	10.1	9.3	42.7	14.7	10.6	11.3
29037 Strathearn	19.6	11.3	34.5	32.1	18.7	15.0	24.0	31.5	34.9	30.8	30.1	15.1	24.8	16.1	17.3[11]
29044 Wark/Beach Blvd.	14.3	12.9	13.9	12.6	10.9	10.8	8.9	10.2	9.4	11.3	14.9	10.4	11.7	11.6	11.9
29046 O.P.P. Bldg Burlington	2.9	3.5	4.8	3.8	2.9	5.7	12.7	2.9	3.2	3.1	8.0	3.5	4.8	6.7	7.2
29067 450 Hughson N.	4.1	8.0	9.0	9.0	8.0	4.6	4.8	5.0	6.0	5.6	-	3.0	6.1	5.8	7.6[11]
29082 Leaside Rd.	6.7	7.4	13.1	11.9	12.3	6.5	11.1	7.3	6.1	6.8	7.5	5.7	8.5	7.7	8.3[9]
29084 Rembe/Beach Blvd.	-	6.7	6.4	5.3	6.3	6.2	6.2	5.4	7.6	5.4	7.8	6.8	6.4[11]	-	-
29086 23 Bayfield Ave.	-	12.0	19.0	18.0	13.0	26.9	7.2	8.5	9.7	7.4	8.8	7.9	12.6[11]	-	-

- Underlined values are above objective

TABLE 5

SULPHUR DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .25
24-hour - .10
1-year - .02

		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park	1979	.012	.14	.08	0	0
	1978	.013	.13	.07	0	0
	1977	.017	.15	.08	0	0
	1976	.021	.30	.11	2	1
29025 - Barton/ Sanford	1979	.017	.25	.10	0	0
	1978	.016	.29	.07	1	0
	1977	.023	.17	.08	0	0
	1976	.021	.24	.09	0	0

TABLE 6

TOTAL REDUCED SULPHUR

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 20 (Hydrogen Sulphide)

		Annual Average	Maximum	No. of Times Above Objective
29008 - North Park	1979	1.6	32	3
	1978	1.2	36	5
	1977	0.8	26	2
	1976	0.8	22	1
29025 - Barton/ Sanford	1979	2.4	144	75
	1978	1.6	66	74
	1977	1.3	110	65
	1976	1.0	41	26

TABLE 7

CARBON MONOXIDE

UNITS - PARTS PER MILLION

Ontario Objective: 1-hour - 30
8-hour - 13

		Annual Average	Maximum 1-hour	Maximum 8-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 8-hour
29025 - Barton/Sanford	1979	1.5	14	9	0	0
	1978	1.2	9	5	0	0
	1977	1.4	12	7	0	0
	1976	1.4	14	7	0	0

TABLE 8

NITROGEN DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .20
24-hour - .10

		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park	1979	.034	.16	.10	0	0
	1978	.040	.14	.11	0	1
	1977	.045	.20	.14	0	3
	1976	.038	.13	.09	0	0
29025 Barton/Sanford	1979	.029	.12	.07	0	0
	1978	.046	.18	.12	0	3
	1977	.057	.18	.13	0	2
	1976	.040	.18	.10	0	0

TABLE 9

NITRIC OXIDE

UNITS - PARTS PER MILLION

		Annual Average	Maximum 1-hour	Maximum 24-hour
29008 - North Park	1979	.068	1.00	.23
	1978	.069	.69	.24
	1977	.073	.71	.34
	1976	.082	.89	.34
29025 - Barton/Sanford	1979	.030	.78	.43
	1978	.026	.60	.15
	1977	.030	.55	.26
	1976	.025	.81	.23

TABLE 10

NITROGEN OXIDES
(Sum of Nitrogen Dioxide and Nitric Oxide)

UNITS - PARTS PER MILLION

			Maximum	
		Annual Average	1-hour	24-hour
29008 - North Park	1979	.101	1.04	.30
	1978	.110	.76	.30
	1977	.117	.77	.40
	1976	.120	.96	.40
29025 - Barton/Sanford	1979	.059	.88	.50
	1978	.073	.64	.22
	1977	.086	.63	.36
	1976	.065	.91	.31

TABLE 11

REACTIVE HYDROCARBONS (NON-METHANE)

UNITS - PARTS PER MILLION

		Annual Average	Maximum 1-hour	Maximum 24-hour
29025 - Barton/Sanford	1979	2.11	5.4	4.2
	1978	1.72	5.4	4.0
	1977	1.89	5.4	4.2
	1976	1.61*	4.7	3.6

* Last five months only

TABLE 12

OZONE

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 80

		Annual Average	Maximum	No. of Times Above Objective
29025 - Barton/Sanford	1979	15.3	112	32
	1978	16.3	119	71
	1977	16.6	92	15
	1976	18.0	128	95

TABLE 13

SULPHATION RATE

MILLIGRAMS SO_3/100 CM^2/DAY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average 1979	Average 1978	Average 1977
29001 Hughson/Hunter	.59	.67	.48	.71	.68	.56	.35	.41	.51	.47	.99	.51	.58	.48	.45
29006 Queenston	.48	.53	.31	.31	.31	.23	.25	.18	.36	.32	1.13	.84	.44	.37[11]	.29
29008 North Park	.89	.90	.30	.60	.42	.91	.77	.79	1.08	1.76	1.93	2.13	1.04	.89	.97
29009 Kenilworth	.64	.78	.89	.44	.42	.31	.34	.30	.46	.46	.64	.80	.54	.46	.48
29011 Burlington/Leeds	.65	.98	-	1.54	1.43	.86	.75	.72	.94	-	2.25	1.36	1.15[10]	.75	.72
29012 Burlington/ Wellington	.46	.60	.30	.46	.74	.37	.38	.33	.68	-	.92	-	.52[10]	.50	.38
29017 Chatham/Frid	1.15	.73	.44	.41	.71	.63	.38	.44	.53	1.53	1.88	.64	.79	.51	.51
29019 Mohawk/Warren	.42	.78	.56	.55	1.16	.47	.47	.32	.75	.85	2.25	1.07	.80	.46	.47
29025 Barton/Sanfor	.53	.75	.23	.67	1.08	.59	-	-	.68	-	1.61	.69	.76[9]	.52	.42
29016 Woodward/Brampton	.64	.78	.48	.47	.38	.36	.46	.36	.27	.50	.61	.70	.50	.48	.48
29030 Mohawk/Camden	.47	.62	-	.55	.74	.39	.42	.33	.63	.79	1.86	1.39	.74[11]	.40	.36
29031 Concession/ Upper Sherman	.65	.78	.70	.67	.76	.51	.48	.38	.72	.64	2.09	.69	.76	.51	.49
29036 Roosevelt/Beach Rd.	.77	.86	-	.79	.77	.45	.52	.53	.91	.64	2.21	.80	.85[11]	.66	.63

TABLE 13 (Cont'd)

SULPHATION RATE

MILLIGRAMS SO_3/100 CM^2/DAY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average 1979	Average 1978	Average 1977
29037 Strathearn	1.98	1.33	1.31	2.27	1.21	1.10	.96	.89	1.19	1.38	2.66	1.71	1.50	.78	.76
29044 Wark/Beach Blvd.	.79	.67	-	.57	.28	.34	.47	.35	.53	.70	1.49	1.11	.66[11]	.57	.55
29046 OPP Building Burlington	.46	.49	.24	.24	.23	.19	.26	.21	.35	.26	-	-	.29[10]	.32[11]	.28
29051 Botanical Gardens Burlington	.32	.41	.17	.20	.27	.17	.24	.14	.15	.25	1.12	.47	.33	.48	.45
29055 LaSalle Park Burlington	.42	.59	-	.24	.31	.26	.33	.23	.50	.31	.44	.50	.38[11]	.41	.33
29067 450 Hughson N.	.46	.52	.25	.24	.34	.18	.23	.21	.31	.27	.44	.53	.33	.35[10]	.34

TABLE 14

FLUORIDATION RATE

ALL VALUES IN MICROGRAMS/100 SQ.CM/30 DAYS

Ontario Criteria: April 15 to October 15 - 40
October 16 to April 14 - 80

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average 1979	1978	1977
29001 Hughson/Hunter	42	44	43	63	71	62	35	46	34	28	25	21	43	41	37
29008 North Park	46	76	32	39	52	80	66	86	28	116	124	164	76	116[11]	98
29012 Burlington/ Wellington	54	41	22	34	46	48	32	40	-	29	23	-	37[10]	43	33[11]
29017 Chatham/Frid	57	50	44	38	71	71	46	64	43	43	31	26	49	51	41
29025 Barton/Sanford	53	78	41	86	115	64	-	-	44	50	32	36	60[10]	52	48
29026 Woodward/Brampton	85	61	32	31	39	46	55	48	32	39	44	41	46	53	48
29054 Beach Rd./Conrad	117	73	38	46	36	77	83	78	60	63	39	57	71	70	69
29058 Q.E.W./Skyway	239	136	134	84	57	100	124	185	77	146	133	166	131	170	135
29059 Burlington/Gage	142	171	69	92	24	-	108	101	83	64	67	103	93	137[10]	84
29062 Briarwood School King St. E.	117	69	111	78	63	62	62	59	48	40	-	-	71[10]	68	63[11]
29066 Killarney/Beach B.	127	95	72	56	38	48	37	60	32	59	93	108	68	110[11]	81

- Underlined values are above objective